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THE THEORY OF RELATIVE-PRICE CHANGES, MONEY, AND DEMAND FACTORS

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The Theory of Relative-Price Changes, Money, and Demand Factors[ζ]

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Abstract

Concentrating on the period of quantitative easing in Japan, this paper re-examines the correlation between the asymmetry of sectoral relative-price changes and the aggregate inflation rate proposed by Ball and Mankiw (1995). While this correlation is widely interpreted as evidence that short-run inflation is determined by supply-side factors, we study whether monetary environment and aggregate demand can explain this correlation, as well as the inflation rate. Using producer price index data, we first show that the positive and significant effect of relative-price change asymmetries on inflation is not robust with respect to various indicators of asymmetry. Second, indicators of aggregate demand and monetary environment *do* affect the measures of asymmetries. Third, demand and monetary factors themselves play roles in explaining inflation. In our examination of the dynamic impact of various factors on inflation, we obtain robust evidence from impulse responses based on vector autoregressive models that demand and money influence inflation and that aggregate demand also affects the asymmetry of relative price-changes. Thus, for the quantitative easing period, we reject the claim that the recent disinflation/deflation period can be understood as primarily a supply-side phenomenon.

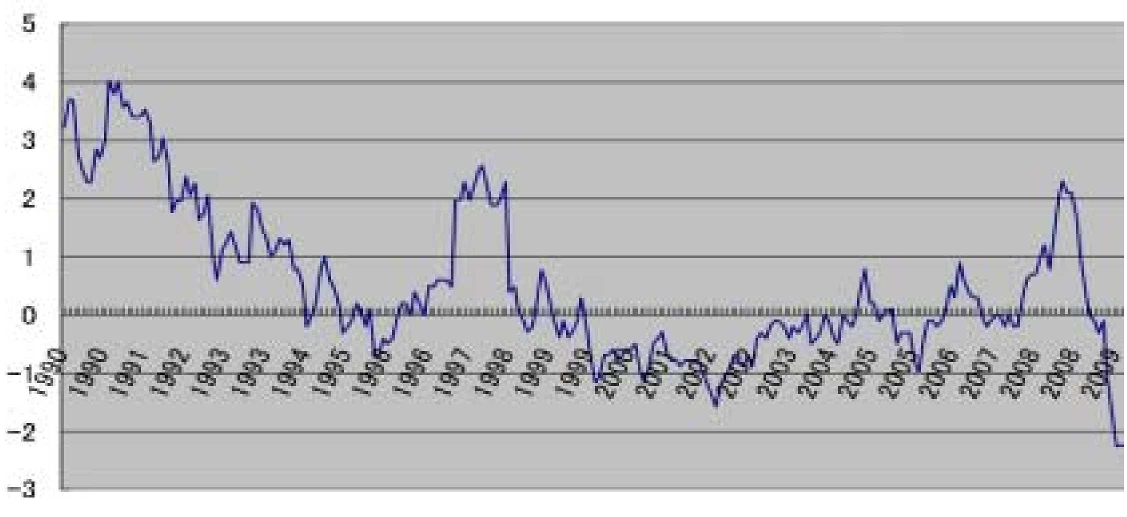
JEL Classifications: E20, E31, E52, E65, O53

Keywords: Japan, supply-side, inflation, deflation, price-change asymmetries, quantitative easing

I. Introduction

Japan has been in a long period of disinflation and deflation[1]. As is shown in Figure 1, the rate of aggregate price change based on the consumer price index declined during most of the Heisei recession (1990-2003), except for a short period around 1997-1998. Moreover, pure deflation became normal after 1999 until late 2007, except for a few hikes above zero. Although the rate then became positive through 2008, more recently it again turned negative. Such a long period of disinflation/deflation, lasting almost twenty years, is a rarity in history[2]. It is no surprise, therefore, that a serious debate arose over the causes and remedies. Although researchers point to various causes, it is appropriate to characterize the nature of the debate as one over supply- versus demand-side factors. Some argue that this disinflation/deflation is mainly a supply-side phenomenon, as it was caused by such factors as lower energy prices or the influx of inexpensive imports. Others maintain that a lack of demand due to the weak economy is the main culprit. If the latter conclusion is more adequate, there can be scope for government actions, while such room is limited if the former view is more appropriate. This debate, vehement during the recession, seems to be revitalized as concerns for a "deflation spiral" loom over the economy.

Figure 1: CPI inflation rate for Japan (1999.01-2009.12)



[1] Disinflation is defined as a decrease in the rate of change of the general price level and deflation as a negative rate. However, as Figure 1 clearly shows, the current deflation is a direct consequence of preceding disinflation, and the concerns over these phenomena are similar. Therefore, it is not inappropriate to use these terms collectively in the form of "disinflation/inflation. "

[2] Another notable example of a long disinflation period is the U.S. from 1979 to the mid 1980s. However, this phase lasted only for about 6 years and the inflation rate never went below zero.

Turning to economic theories, an academic discourse runs parallel to this debate. Although there is a consensus that growth in the money supply is the main determinant of inflation in the long-run, theorists disagree on the determinants of inflation in the short-run.[3] This debate is also heavily influenced by the question of whether supply-side or demand-side factors are primarily responsible for movements in prices. Traditional Keynesians emphasize the importance of fiscal policy and aggregate demand; classical economists stress the importance of supply-side factors; and monetarists note the relevance of an inappropriately conducted monetary policy in addition to the supply side. New Keynesian approaches no longer discount the potential importance of supply-side factors. Instead, rigidities are no longer assumed *a priori* but are explained within a framework of microeconomic optimization behavior. Of particular relevance in the context of explaining short-run inflation is a theory put forward by Ball and Mankiw (1995), which has attracted much attention since its publication. Assuming imperfect competition due to menu cost pricing and monopolistic competition, they show that large, but not small, positive (negative) sectoral shocks skew the distribution of relative-price changes across sectors to the right (left) and push up (down) the mean of the updated prices simultaneously. Empirically, this implies a positive correlation between the skewness of the price distribution and the rate of change of the aggregate price level. They provide empirical evidence for their theory using data on the United States. Thus, nominal price rigidity can be explained consistently within a framework based on neoclassical microeconomic foundations.

Following Ball and Mankiw (1995), many papers have investigated the validity of this hypothesis for many countries. See, for example, Amano and Macklem (1997) for Canada, Demery and Duck (2008) for the U.S., Dopke and Pierdzioch (2001) for Germany, and Mendez-Carbajo and Thomakos (2004) for Spain. There are only few studies that test this theory for Japan. Using data on the consumer price index, Watanabe et al. (2003) detect a positive correlation between the inflation rate and price asymmetry over the period 1971-2002. Using the method of a random cross section sample split to address the small sample issue pointed out by Ceccheti and Bryan (1999), Gerlach and Kugler (2007) confirmed their finding for the period 1981-1986. However, Holly (1997) controlled for the growth in money

[3] As deflation is negative inflation, from now on, the term "inflation "is used to encompass both increase and decrease of the general price level.

and rejected the Ball and Mankiw (1995) hypothesis, based on Japanese wholesale price data for 1976-1994.

Presumably because Ball and Mankiw (1995) themselves presented it to be mainly a supply-side theory, many people associate the success of this theory with that of the supply-side theory on short-run inflation[4]. However, we argue that such a conclusion is not warranted, because demand-side factors can also cause the distribution of sectoral relative-price changes to skew. Ball and Mankiw (1995) note in passing that demand factors may also be responsible but do not follow up on this point. For instance, if a monetary policy shock influences demand in different sectors differently, then the distribution of sectoral relative-price changes is affected by the demand side. There is considerable empirical evidence for such asymmetric effects of monetary policy (Hayo and Uhlenbrock 2000, Dedola and Lippi 2005, Peersman and Smets 2005). More generally, any rise in aggregate demand that causes sector-specific changes may also generate sectoral relative-price changes and thereby bring about a skewed distribution. Therefore, the positive correlation between skewness and inflation can be due to both supply-side and demand-side factors.

The purpose of this paper is to examine whether "monetary policy and other determinants of aggregate demand have important roles" (Ball and Mankiw 1995, p.161, l17) for explaining the short-run behavior of inflation, in the context of the recent Japanese episode of disinflation/deflation. In other words, we question the association of the positive asymmetry-inflation correlation with the supply-side hypothesis. To bring out this neglected aspect in the above-mentioned demand-supply debate, we choose the economic situation of Japan in recent years. To circumvent a number of methodological problems, we do the following. First, to derive an identifiable indicator of monetary conditions in Japan, we concentrate on the period of quantitative easing as conducted by the Bank of Japan, from March 2001 to March 2006. During this time, widely-used indicators, such as short-term interest rates or changes in the money supply, do not work. Thus, we construct an indicator

[4] For instance, Watanabe et al. (2003, 220) state that they measured the supply shock by examining how the distribution is skewed to the left and that the detected positive correlation may be a reflection of international transfers of technology and influx of inexpensive imports from China. Demery and Duck (2007) claim that the failure to detect such a correlation in their estimations is evidence against the supply-side explanation of inflation, referring to Fisher's (1981) comment on the positive correlation between the first and *second* moments of the relative-price changes.

based on the commercial banks' excess reserve at the Bank of Japan. Second, we directly examine the relationship between the measured asymmetry of sectoral relative-price changes, on the one hand, and the monetary policy and a measure of aggregate demand on the other. Third, to get a better grasp of the dynamic nature of the effects, we employ impulse response analysis in addition to simple time-series regressions.

The paper is organized as follows. The next section derives various indicators of relative price-change asymmetries and then reexamines, with a battery of such indicators, whether these asymmetries affect inflation. Section III studies whether the demand-side factors and the monetary environment affect the various measures of relative-price change asymmetries. Section IV, combining the main factors affecting short-run inflation in one model, investigates whether price asymmetries actually play a noteworthy role. Section V studies the dynamic impact of supply, demand, and monetary shocks on inflation, by examining impulse responses based on vector autoregressive (VAR) models. The final section concludes the paper with a summary, caveats, and venues for future extensions.

II. Re-examination of the Impact of Asymmetric Relative Price Changes

In this section, as a first step we want to re-examine, with data on Japan for the period of quantitative easing, whether price asymmetries affect inflation, as has been found by Ball and Mankiw (1995) for the US and by Watanabe et al. (2003) for Japan. From the various price series available, we follow Ball and Mankiw (1995) in choosing producer prices. This indicator is closer than consumer prices to the underlying hypothesis regarding the price setting of firms and is not subject to the typical price-smoothing behaviour of retail companies, which is mainly responsible for the relatively lower variation of consumer prices.

Ball and Mankiw (1995) suggest various alternative indicators for measuring the asymmetries of relative-price change. Apart from skewness (the third moment) of the underlying price data, they look at:

$$\mathrm{AsymX} = \int_{-\infty}^{-x} \mathrm{r}\,\mathrm{h}(\mathrm{r})\,\mathrm{dr} + \int_{x}^{\infty} \mathrm{r}\,\mathrm{h}(\mathrm{r})\,\mathrm{dr} \qquad (1)$$

where: r: industry relative-price change (industry inflation rate minus the mean of industry inflation rates), h(r): density of r, including the weighing for industry size.

Relative-price changes greater than X and smaller than –X define the tails of the distribution. We employ cut-off points X =10 and X = 5, which yield variables Asym10 and Asym5, i.e. capturing relative price changes greater than 10 or 5 percent, respectively. A third indicator, ASYMQ does not assume a specific cut-off point but rather lets the weights on the relative price changes increase linearly with the size of the adjustments:

$$AsymQ = \int_{-\infty}^{\infty} |r| r h(r) dr \quad (2)$$

These three indicators are zero for symmetric distributions and their values increase with the variance, which magnifies the tails. For positive values of Asym, the right tail of the distribution is larger than the left tail and vice versa.

Watanabe et al. (2003) argue that the Asym indicators are suboptimal, as they could lead to a ‘spurious’ correlation with inflation if the latter is positively correlated with the standard deviation of prices. Instead, they propose a class of alternative indicators, which are immune to this problem.

$$SX = \sum_{i \in I_L \cup I_R} \omega_i v_i \quad (3)$$

where: v_i : relative price change of the i^th item,

ω_i : weight thereof,

$I_L \equiv \{ j \mid v_i \in (-\infty, L] \}$,

$I_R \equiv \{ j \mid v_i \in [R, -\infty, L) \}$,

and L is chosen such that the sum of all ω_i with the corresponding v_i satisfying $\{ v_i \in (-\infty, L] \}$ is X (e.g. if X = 15, items are picked up in ascending order until the sum of their weights becomes 0.15). R is chosen similarly. Given that in our dataset there is indeed a positive correlation between inflation and the standard deviation, albeit relatively weak, with a correlation coefficient of 0.19, we also compute asymmetry indicators for X = 15 and X = 5, S15 and S5 respectively.

Table 1 provides correlation coefficients for the various indicators of price asymmetry. Whereas all correlations between the indicators are positive, their strengths vary considerably. Thus, we feel confident that we have computed a range of related but still different indicators for price asymmetries, which should provide a sound basis for drawing robust conclusions.

Table 1: Correlations Matrix between Skewness and Alternative Indicators of Price Asymmetry

	ASYM5	ASYM10	ASYMQ	S5	S15
SKEW	0.57	0.62	0.75	0.73	0.66
ASYM5	1	0.42	0.84	0.82	0.69
ASYM10		1	0.66	0.41	0.36
ASYMQ			1	0.92	0.88
S5				1	0.94
S15					1

Employing these various indicators, we examine whether the result of Ball and Mankiw (1995) holds in our sample. Table 2 contains the outcome of regressions of producer price inflation on the various indicators of asymmetric shocks. The coefficient of determination is very high, but this is mainly due to the lagged inflation variable. Although the coefficient is close to unity, Japanese inflation over this time period does not appear to experience stochastic nonstationarity. Both the augmented Dickey-Fuller test (H_0: nonstationarity) and the Kwiatkowski et al. test (H_0: stationarity) indicate a stationary series at the 5% level.

Our results are only partially in accordance with the evidence presented in Ball and Mankiw (1995), Watanabe et al. (2003), and Gerlach and Kugler (2007). In the basic model (1), only the standard deviation has a significantly positive impact on inflation, whereas skewness is insignificant.

In model (2), we add the interaction of standard deviation and skewness and find that it is not significant, neither using robust standard errors nor using normal standard errors. The standard deviation remains significant. For the alternative indicators of asymmetric price shocks based on Ball and Mankiw (1995) in models (3), (4), and (5), we do not find significant results. Finally, the asymmetry indicators S5 and S15 based on Watanabe et al. (2003) in models (6) and (7) fare much better. They are individually significant at the 5% and 1% levels, respectively, whereas the standard deviation is now insignificant. Thus, for some indicators, we find that asymmetric price shocks affect the inflation rate in Japan during the period of quantitative easing; for others, we do not.

In a next step, we analyse whether the asymmetry in prices can be attributed solely to supply conditions, as tentatively suggested by Ball and Mankiw (1995) and argued by Watanabe et al. (2002).

Table 2: Explaining Inflation by Price Asymmetry Indicators

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-0.003* (0.001)	-0.003* (0.001)	-0.002* (0.001)	-0.003** (0.001)	-0.002(*) (0.001)	-0.002(*) (0.001)	-0.002 (0.001)
Lagged inflation	0.996** (0.020)	0.995** (0.020)	1.002** (0.019)	1.002** (0.020)	0.996** (0.019)	0.991** (0.014)	0.982** (0.014)
Standard Deviation	0.254** (0.084)	0.268* (0.107)	0.250* (0.097)	0.273** (0.071)	0.215* (0.107)	0.210(*) (0.105)	0.189(*) (0.106)
Skewness	0.0001 (0.0001)	-0.0003 (0.0005)					
Skewness by Standard Deviation		-0.011 (0.041)					
ASYM5			0.265 (0.393)				
ASYM10				-0.172 (1.122)			
ASYMQ					6.50		

					(5.284)		
S5						1.042(*) (0.531)	
S15							1.115* (0.430)
Standard error	0.0022	0.0022	0.0022	0.0022	0.0022	0.0021	0.0020
F test	1549**	1144**	1100**	1510**	1585**	1734**	1883**
Adjusted R^2	0.987	0.987	0.987	0.988	0.988	0.989	0.989
Autocorrelation (4th order)	F(4,53) = 2.10(*)	F(4,53) = 2.08 (*)	F(4,53) = 2.17(*)	F(4,53) = 2.27(*)	F(4,53) = 2.17(*)	F(4,53) = 1.61	F(4,53) = 1.33
Heteroscedasticity	F(9,51) = 1.98(*)	F(13,47) = 1.45	F(9,51) = 2.86**	F(9,51) = 1.86(*)	F(9,51) = 3.37**	F(9,51) = 6.22**	F(9,51) = 6.71**

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Standard errors are given in parenthesis. Standard errors based on White (1980) are used for t-tests if heteroscedasticity was detected. Newey-West standard errors are used for t-tests if autocorrelation was detected.

III. Origins of Asymmetric Price Changes

Asymmetry of relative-price changes is typically interpreted as a supply-side phenomenon, and although Ball and Mankiw (1995) acknowledge that demand-side factors may also play a role in generating asymmetric price distributions, they do not follow up on this possibility[5]. Gerlach and Kugler (2007) assume from the start of their analyses that skewness reflects pure supply-side effects. Watanabe et al. (2003) approach the issue a little more cautiously; they observe the time profile of their asymmetry indicator over the business cycle. Noting that it is not pro-cyclical, they conclude that the asymmetry is indeed a supply shock, but do not conduct any rigorous analysis to investigate the issue.[6] In this section, we study, in a more formal way, whether demand-side factors and the monetary environment affect the distribution of Japanese producer relative-price changes and thereby raise doubts about the supply-side interpretation during the quantitative easing period.

The developments in aggregate demand can be proxied by changes in shipments of industrial goods in the Industrial Production Index (IPI). IPI also contains data on production as well as inventory, but we believe that the shipment is a better proxy because production and inventory could reflect supply-side factors. One may argue that shipments are not necessarily equal to sales. Taking that into account, we construct an additional indicator that is based on shipments adjusted for returns as a change in inventory within a period of three months[7]. Table 3 contains estimates of the effects of the two demand indicators on the various proxies for asymmetry. Models (8)–(14) incorporate the effect of the change in shipments variables without accounting for returns. There is a positive and significant effect of demand conditions on the distribution of prices except in the case of ASYM5 and ASYM10. A similar conclusion holds when adjusting the demand indicator for returns within a three

[5] Ball and Mankiw (1995) state (p.169, l7), referring a sectorial shock, "one can interpret the shock as a shift in the industry demand or cost function," but only mention a monetary shock as one such demand factor ,without incorporating it into their regressions.

[6] They also include the output gap as well as change in money supply in their regressions. They then show the asymmetry survives multi-collineality, *i.e.* it still holds positive and significant. Although such evidence lends some support to the interpretation, it does not preclude the possibility that the demand factor is reflected in the asymmetry, as will be shown in our analyses later.

[7] We also constructed the indicator with periods of one and two months, but the results in the following analyses are basically unchanged.

months period, as can be seen from the outcomes of models (15)–(21). The explanatory power of demand is particularly high in the case of S15.

In the second part of analysis of factors influencing asymmetry indicators, we focus on the monetary environment. In deriving a proxy for the monetary environment during times of quantitative easing, we start with the total current accounts of financial institutions held at the Bank of Japan and subtract reserve requirements, as these will limit private banks' abilities to generate money. Thus, we concentrate on excess reserves that, arguably, lie at the heart of quantitative easing. To avoid problems of nonstationarity and to provide a consistent proxy linking the monetary environment with long-run inflation, rather than using the level of absolute excess reserves, we standardize the variable with regard to production and the level of prices.[8]

Table 4 provides estimates of the effects of the monetary environment on the various asymmetry indicators. The outcomes of all models except (24) reveal that the monetary environment has a significant effect on the various indicators of asymmetric relative-price changes. As before, the best fit is found in regressions on S15.

Typically, monetary developments take some time to carry over to prices, and thus there could be concerns that we should specify longer adjustment lags. We also find this to be the case in our dataset, as can be seen from the dynamic analysis below. However, in the present modelling framework, it can also be shown that using lags of the monetary environment indicator does not affect the significance of this variable. For instance, in the case of the skewness variable, the p-values for lags 2, 4, 6, and 8 of the monetary indicator are 0.001, 0.005, 0.01, and 0.02, respectively.

Thus, we find a significant effect of demand and monetary environment on the asymmetry indicators in the majority of our specifications. In our view, this raises doubts that these proposed price distribution indicators are pure proxies of supply conditions originating from the firm level. The above results suggest instead that they also contain influences from the

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[8] Starting from a variant of the quantity equation M K = P Y, with M = excess reserves, K = velocity, P = price level, and Y = output, we take logarithms and get $\ln(M/Y)_t + \ln k_t = \ln P_t$. Assuming that velocity equals unity and subtracting $\ln P_{t-1}$ from both sides of the equation yields $\ln(M/Y)_t - \ln P_{t-1} = \ln P_t - \ln P_{t-1}$. Thus, we use $\ln(M/Y)_t - \ln P_{t-1}$ as our indicator for the monetary environment.

demand side and the monetary environment that have sectoral, in addition to aggregate, effects. This suggests that short-term inflation in Japan during the phase of quantitative easing could be explained by various factors: demand side, supply side, and monetary environment.

Table 3: Explaining Indicators of Price Asymmetry by Demand Conditions

Model	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Dependent variable:	Standard deviation	Skewness	ASYM5	ASYM10	ASYMQ	S5	S15
Constant	0.01** (0.0004)	0.83* (0.35)	0.0003* (0.0001)	0.0007(*) (0.0004)	0.00003* (0.00001)	0.0002(*) (0.0001)	-0.00004 (0.0001)
Demand conditions	**0.02*** (0.006)	**17.2**** (6.44)	0.002 (0.002)	0.001 (0.0007)	**0.0004*** (0.0002)	**0.005*** (0.002)	**0.008**** (0.002)
Standard error	0.004	2.66	0.001	0.0004	0.0001	0.001	0.001
F test	2.18	7.12**	0.49	1.32	4.74*	6.57*	11.95**
Adjusted R^2	0.02	0.09	-0.01	0.01	0.06	0.09	0.15
Autocorrelation	F(4,55) = 7.79	F(4,55) = 0.86	F(4,55) = 0.83	F(4,55) = 3.59*	F(4,55) = 0.45	F(4,55) = 0.22	F(4,55) = 0.45
Heteroscedasticity	F(2,58) = 0.34	F(2,58) = 0.17	F(2,58) = 0.14	F(2,58) = 0.38	F(2,58) = 0.06	F(2,58) = 0.11	F(2,58) = 0.43

Model	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Dependent variable:	Standard deviation	Skewness	ASYM5	ASYM10	ASYMQ	S5	S15
Constant	0.01** (0.0004)	0.64(*) (0.37)	0.0003* (0.0001)	0.0006 (0.0004)	0.00002(*) (0.00001)	0.001 (0.0001)	-0.00004 (0.0001)
Demand conditions excluding returns	0.007* (0.003)	7.52* (3.00)	0.001 (0.001)	0.0005 (0.0003)	0.0002* (0.0001)	0.002* (0.001)	0.003** (0.001)
Standard error	0.004	2.67	0.001	0.0004	0.0001	0.001	0.001
F test	2.14	6.28*	0.69	1.28	4.14*	5.16*	8.46**
Adjusted R^2	0.02	0.08	0.01	0.005	0.05	0.07	0.11
Autocorrelation	F(4,55) = 8.21	F(4,55) = 0.77	F(4,55) = 0.89	F(4,55) = 3.48*	F(4,55) = 0.39	F(4,55) = 0.22	F(4,55) = 0.66
Heteroscedasticity	F(2,58) = 0.46	F(2,58) = 0.58	F(2,58) = 0.31	F(2,58) = 0.41	F(2,58) = 0.36	F(2,58) = 0.44	F(2,58) = 0.67

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Standard errors are given in parenthesis. Newey-West standard errors are used for t-tests if autocorrelation was detected.

Table 4: Explaining Indicators of Price Asymmetry by the Monetary Environment

Model	(22)	(23)	(24)	(25)	(26)	(27)	(28)
Dependent variable:	Standard deviation	Skewness	ASYM5	ASYM10	ASYMQ	S5	S15
Constant	0.017** (0.002)	5.43** (1.517)	0.0007 (0.0006)	0.0003* (0.0001)	0.0001** (0.00005)	0.001** (0.0005)	0.002** (0.0005)
Monetary environment	**0.0008**** (0.0003)	**0.857**** (0.285)	0.0001 (0.0001)	**0.00005*** (0.00002)	**0.00002*** (0.00001)	**0.0002*** (0.00009)	**0.0003**** (0.0001)
Standard error	0.004	2.62	0.001	0.0004	0.0001	0.001	0.001
F test	3.38(*)	9.04**	0.45	1.41	5.37*	7.06*	9.98**
Adjusted R^2	0.04	0.12	-0.01	0.02	0.07	0.09	0.16
Autocorrelation	F(4,55) = 8.66**	F(4,55) = 1.09	F(4,55) = 1.00	F(4,55) = 3.58*	F(4,55) = 0.28	F(4,55) = 0.24	F(4,55) = 0.28
Heteroscedasticity	F(2,58) = 0.60	F(2,58) = 1.41	F(2,58) = 0.18	F(2,58) = 1.53	F(2,58) = 0.37	F(2,58) = 0.01	F(2,58) = 0.07

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Standard errors are given in parenthesis. Newey-West standard errors are used for t-tests if autocorrelation was detected.

IV. The Impact of Asymmetric Price Changes, Demand Conditions, and the Monetary Environment on Inflation

In this section, we combine the various factors affecting short-run inflation in one model to investigate whether price asymmetries play a noteworthy role over this specific phase in Japanese monetary history. The first three models in Table 5 use skewness as the asymmetry indicator.[9] Model (29) shows that the significantly positive impact of the monetary environment on the inflation rate found in the bivariate context holds up in a multivariate framework as well. Demand conditions are also significant, as can be seen in model (30). Moreover, model (31) indicates that this is the case even after controlling for returns to the producers three months after shipment. Switching the price asymmetry indicator from skewness to Asym5 and including both monetary environment and demand conditions shows in model (32) that the former is not significant, while the latter are. Moreover, there is notable collinearity between monetary environment and demand conditions, which implies that jointly they are even significant at a 1% level ($F(2, 57) = 5.02^{**}$). An equivalent conclusion holds in the case of Asym10 in model (33) and AsymQ in model (34).

Employing the Watanabe et al. (2003) indicators S5 and S15 in models (35) and (36), respectively, we get a somewhat different outcome. Whereas S5 is still insignificant at a 10% level, in the case of S15 price asymmetries matter and they have a significantly positive effect on inflation, in line with the hypothesis advanced by Ball and Mankiw (1995). However, demand continues to have a significant influence on inflation rates. Moreover, it was shown above in models 15 and 21 that demand has a significant effect on S15, which implies that demand affects inflation over and above its influence on the asymmetry of relative-changes in prices. Model demonstrates that for S15, the monetary environment variable has the highest explanatory power of any asymmetry indicator. This suggests that, at least to some extent, S15 reflects the influence of the monetary environment. Thus, even in the only model where an asymmetry indicator is significant do we find a significant influence of factors that are unrelated to supply.

[9] Note that the interaction of skewness and standard deviation that showed a lot of promise in Ball and Mankiw's (1995) study is never significant in any of the constellations we looked at and has been omitted for brevity reasons.

Table 5: Explaining Producer Price Inflation by Asymmetric Price Changes, Demand Conditions, and the Monetary Environment

Model	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
Constant	0.0005 (0.002)	-0.002** (0.001)	-0.003** (0.001)	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)
Lagged inflation	0.981** (0.017)	0.973** (0.016)	0.985** (0.015)	0.971** (0.017)	0.971** (0.018)	0.968** (0.017)	0.967** (0.016)	0.961** (0.015)
Standard Deviation	0.235** (0.069)	0.232** (0.065)	0.230** (0.103)	0.218** (0.067)	0.236** (0.081)	0.194** (0.070)	0.191(*) (0.098)	0.176(*) (0.102)
Skewness	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)					
ASYM5				0.203 (0.284)				
ASYM10					-0.178 (1.298)			
ASYMQ						4.767 (3.645)		
S5							0.829 (0.501)	
S15								0.909*

								(0.417)
Monetary environment	**0.0005(*)** (0.0003			0.0003 (0.0003)	0.0003 (0.0002)	0.0002 (0.0003)	0.0002 (0.0002)	0.0002 (0.0002)
Demand conditions		**0.019**** (0.006)		**0.016*** (0.006)	**0.017**** (0.007)	**0.016*** (0.006)	**0.015**** (0.005)	**0.013*** (0.005)
Demand conditions excluding returns			**0.008**** (0.003)					
Standard error	0.0022	0.0021	0.0021	0.0021	0.0021	0.0020	0.0020	0.0019
F test	1210**	1338**	1328**	1066**	1058**	1090**	1167**	1241**
Adjusted R^2	0.988	0.989	0.989	0.989	0.989	0.989	0.990	0.990
Autocorrelation	$F(4,52) = 2.05$	$F(4,52) = 1.19$	$F(4,52) = 1.77$	$F(4,51) = 1.17$	$F(4,51) = 1.20$	$F(4,51) = 1.23$	$F(4,51) = 0.90$	$F(4,51) = 0.82$
Heteroscedasticity	$F(14,46) = 1.52$	$F(14,46) = 1.26$	$F(14,46) = 1.51$	$F(20,40) = 1.56$	$F(20,40) =$ 3.46**	$F(20,40) = 1.23$	$F(20,40) =$ 3.11**	$F(20,40) =$ 4.31**

Note: Number of observations: 63. (*), *, and ** indicate significance at 10%, 5%, and 1% levels, respectively. Standard errors are given in parenthesis. Standard errors based on White (1980) are used for t-tests if heteroscedasticity was detected.

We showed above that demand conditions and monetary environment affect the asymmetry indicators. Now we see that even after controlling for asymmetry indicators, these factors continue playing a role. This suggests that demand conditions and monetary environment affect inflation through two channels: First, there is the direct effect just discussed. Second, Table 3 and 4 above show evidence of a significant impact of these two factors on the S15 Watanabe et al. (2003) price asymmetry indicator. Thus, model (36) suggests an additional indirect influence of these indicators on inflation through their impact on S15.

To conclude, inflation during the phase of quantitative easing was influenced by the monetary environment, demand conditions, and supply conditions. In the next step of our analysis, we look more closely at the dynamic relationship between these variables.

V. Dynamic Impact of Supply, Demand, and Monetary Shocks on Inflation

For the analysis of the dynamic impact of supply, demand, and monetary shocks, we estimate vector autoregressive (VAR) models. We employ variables in levels, which yields a convenient interpretation in terms of shocks.[10] As before, we follow Ball and Mankiw (1995) by using the more theory-consistent producer price index, with skewness and standard deviation as the supply side indicators. As shown above, the alternative indicators for price asymmetries put forward by these authors behave rather similarly. However, in the period of quantitative easing in Japan, the Watanabe et al. (2003) indicator S15 appears to be a much stronger predictor of inflation. It is therefore interesting to see whether the inclusion of this variable as an alternative to skewness affects the outcome of the analysis. In addition,

[10] In using level variables in spite of the fact that some could be non-stationary, we follow the argument in Sims (1991).

we control for international supply-side shocks with the help of an index of energy prices. Monetary shocks are derived by including excess reserves held by private financial institutions at the Bank of Japan, and demand shocks are based on the delivery of goods.

The length of the VARs is chosen based on information criteria and for the present data is set at 2 lags. To avoid ambiguities in the results of the impulse response functions arising from an arbitrary ordering of the variables, we use generalised impulse-responses (Pesaran and Shin 1998), which generate an orthogonal set of innovations that does not depend on the VAR ordering. The confidence bands are derived using analytic methods based on asymptotic theory and provide significant tests at a significance level of approximately 5%.

Figure 2 presents the dynamic reaction of producer prices to a one standard deviation shock in the assorted variables. A shock in energy prices causes an increase in the price level, which is in line with our expectations about a supply shock. An increase in the standard deviation yields higher prices, and so does more skewness. Thus, we find evidence in a dynamic setting that the variables put forward by Ball and Mankiw (1995) explain price developments in Japan during the phase of quantitative easing. In addition, demand shocks also move prices upward, and so do monetary shocks. The time profiles of the price reactions to these variables appear to be plausible, with demand shocks generating a quick impact on prices, whereas monetary shocks are characterised by longer transmission lags.

Substituting skewness for the price asymmetry indicator suggested by Watanabe et al. (2003) yields a similar picture (see Figure 3). The price asymmetry effect is even more pronounced, whereas the impacts of demand and monetary shocks are basically unchanged. Thus, prices in Japan react to asymmetry shocks as well as to demand and monetary shocks.

However, our results above indicate that the asymmetry indicator should not be interpreted as reflecting pure supply-side effects. The VAR framework allows study of the relationship between price asymmetry indicators in a dynamic setting. Figure 4 shows how skewness reacts to shocks in the other variables. First, note that the dynamic adjustments happen much quicker than in the responses of producer prices. Second, skewness will increase after a price shock. Thus, there appears to be a feedback relationship between skewness and the level of prices. Third, energy prices affect skewness positively, whereas the standard deviation does not affect skewness much, a result that runs against the expected relationship noted by Ball and Mankiw (1995). Fourth, a monetary shock has a positive but very small effect on skewness. Fifth, there is a statistically significant and economically relevant positive effect of demand shocks on skewness. Hence, this is more evidence of our claim that price skewness as an indicator does not only reflect supply-side effects.

Figure 5 investigates the relationship using S15 instead of skewness. The qualitative results do not change. However, notable differences lie in a much stronger reaction of the price asymmetry indicator to producer price shocks and energy price shocks. The feedback relationship between prices and the asymmetry indicator noted above is now even stronger than before.

When considering the other effects within the VAR, a rather complicated picture emerges. To economize on space, in Figure 6 we show a stylized summary of the relationship between producer prices, skewness, and the other indicators based on the impulse response functions. To avoid cluttering the figure, we concentrate our attention on the shocks affecting the three PPI-related variables that are both statistically significant as well as quantitatively relevant.

The arrows indicate significantly positive effects of shocks in one variable on another variable. Thus, all the listed factors increase producer prices in Japan. However, in addition to these direct effects, demand-side shocks increase skewness. Thus, as a result of higher demand, producer prices increase directly and indirectly through the mechanism outlined by Ball and Mankiw (1995). Thus, skewness cannot be interpreted as a pure supply-side indicator.

Figure 2: Responses of the Producer Price Index to Orthogonal Shocks (including Skewness)

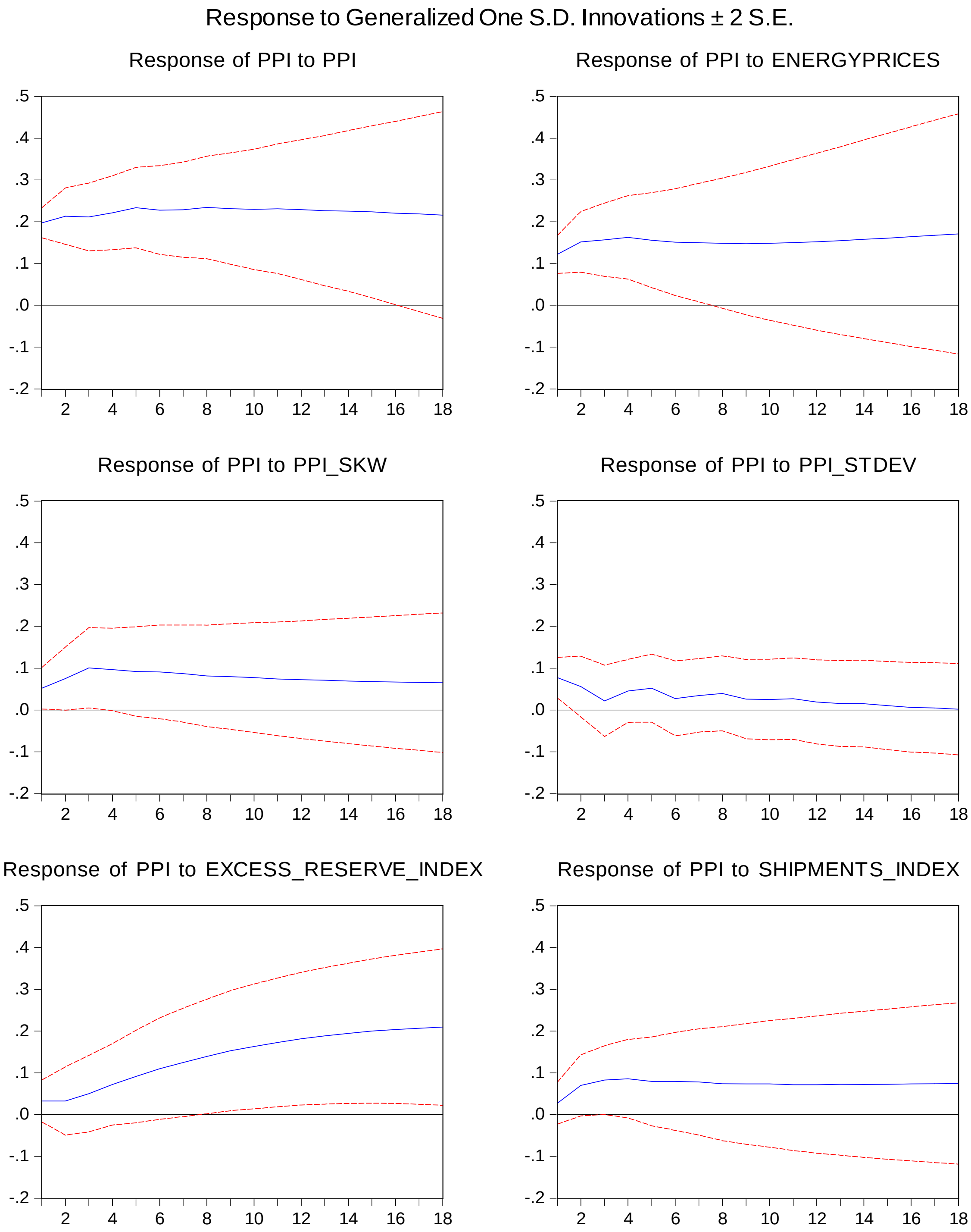


Figure 3: Responses of the Producer Price Index to Orthogonal Shocks (including S15)

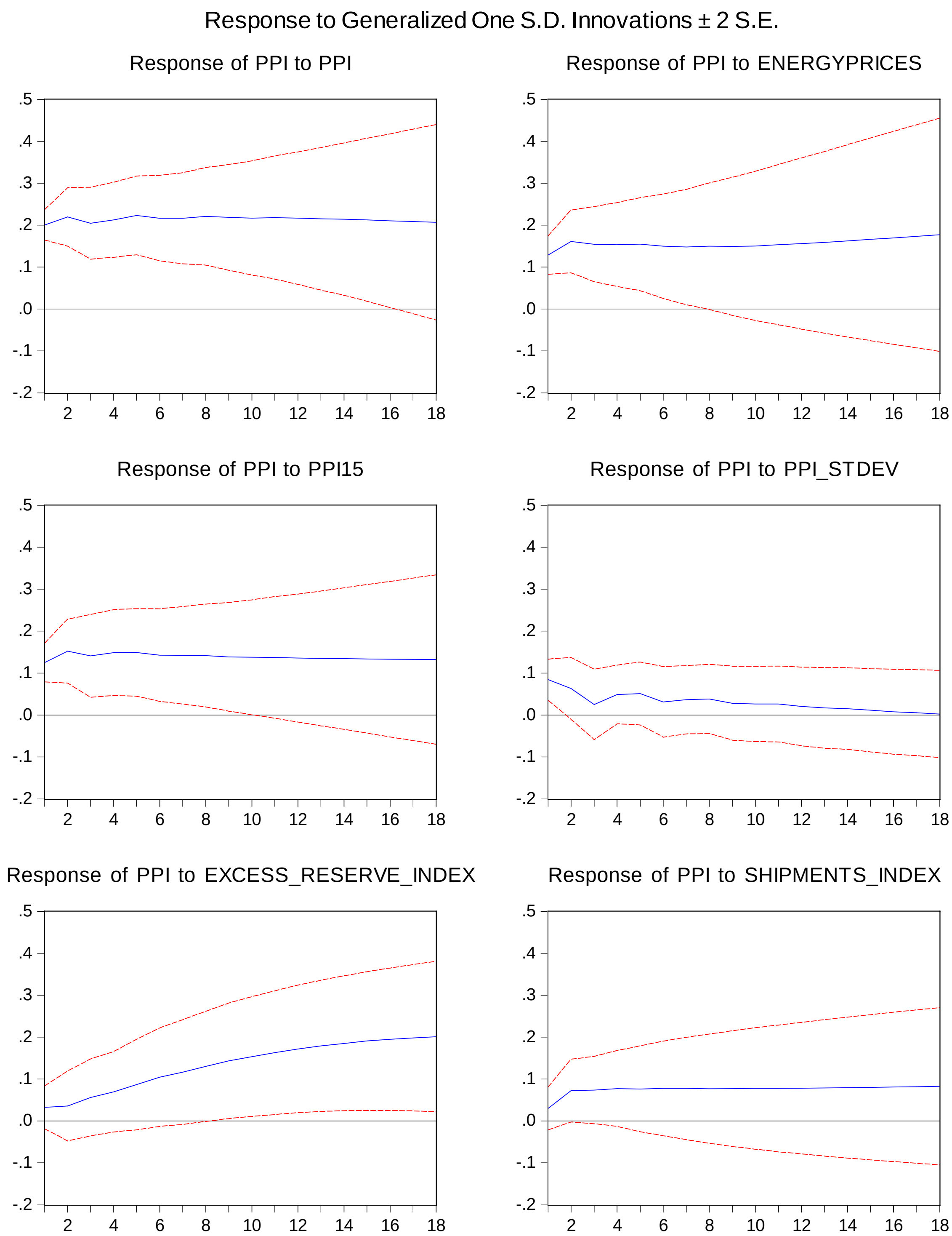


Figure 4: Responses of Skewness to Orthogonal Shocks

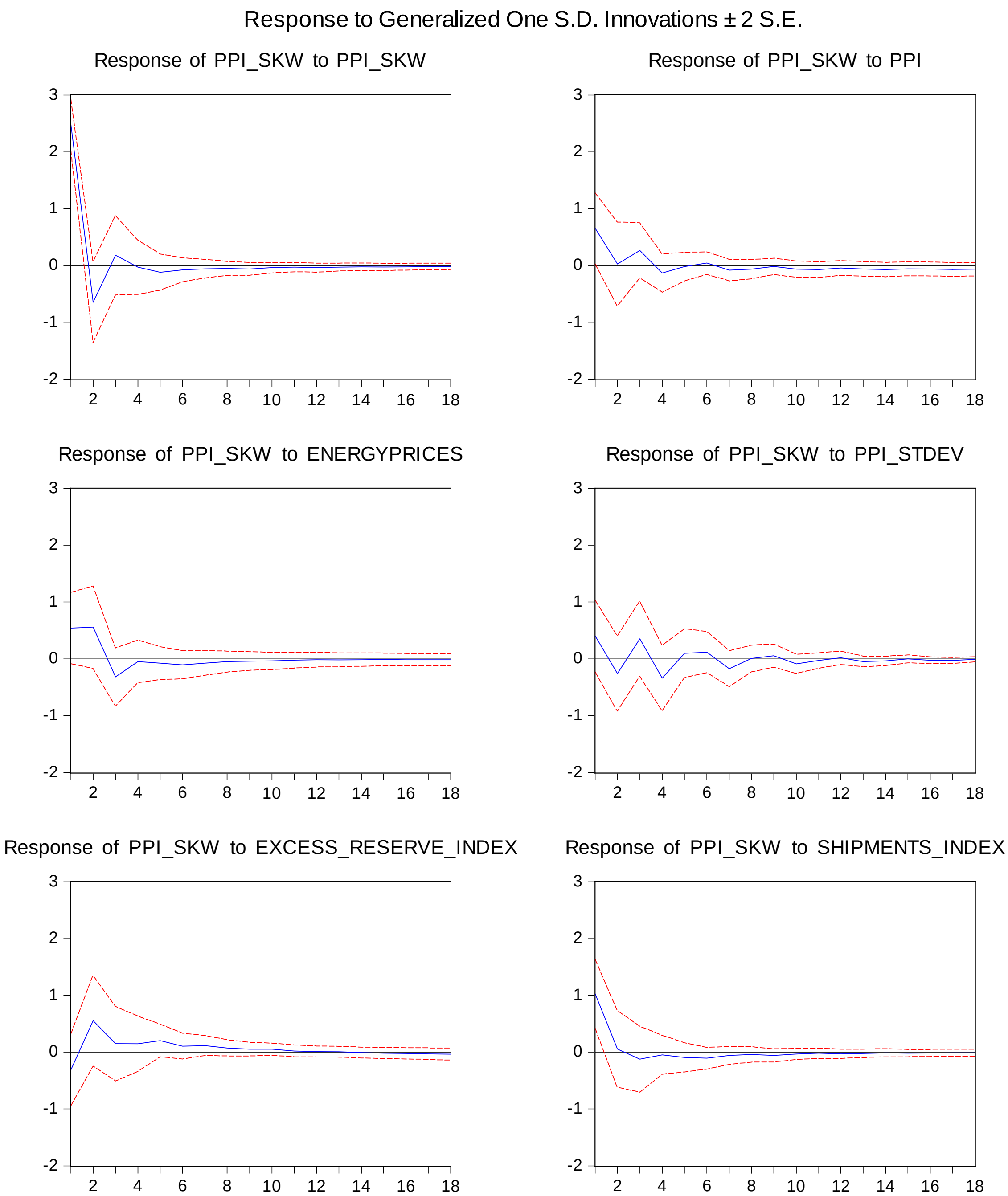


Figure 5: Responses of S15 to Orthogonal Shocks

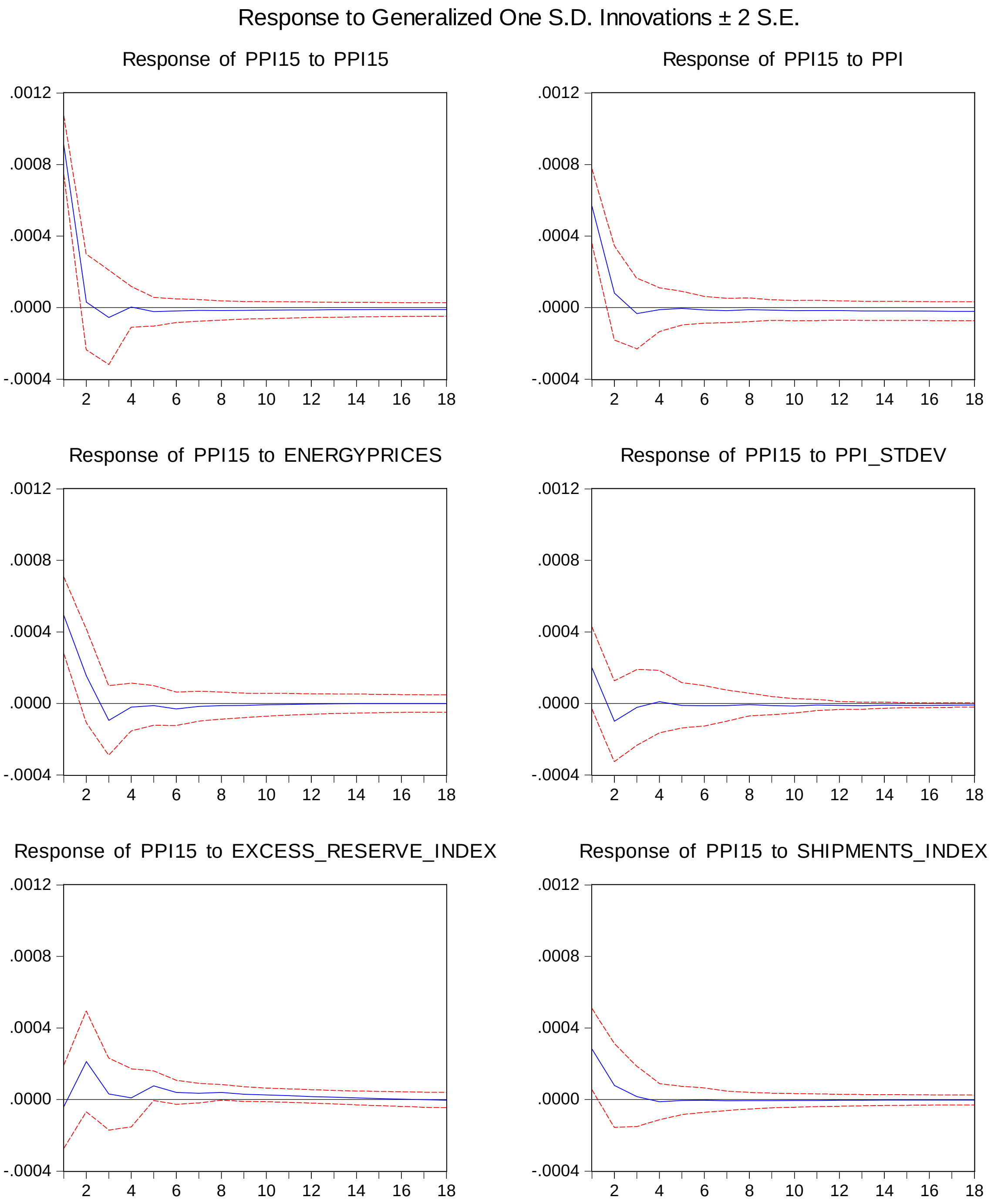
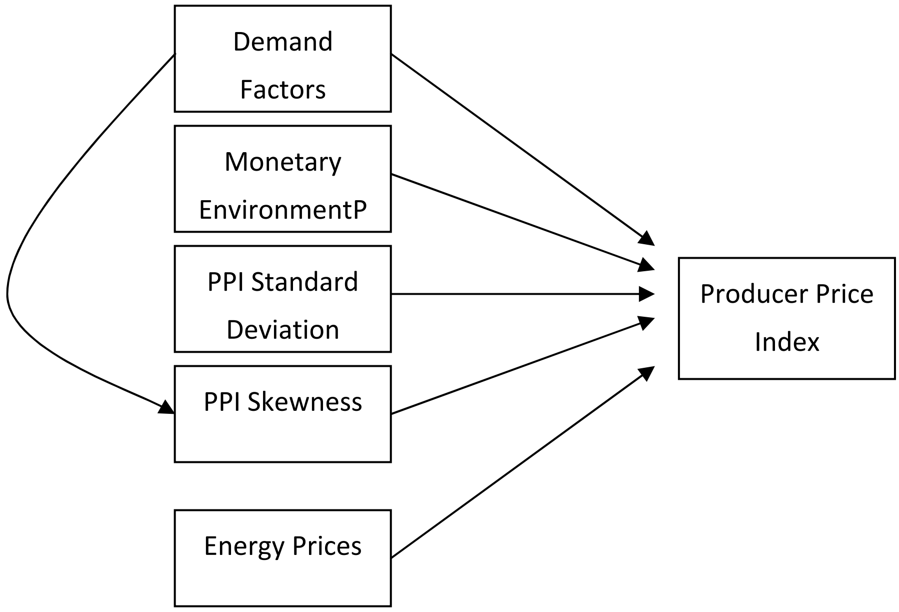


Figure 6: Relationship between Producer Prices, Skewness, Monetary and Demand Factors



VI. Conclusions

Japan has been experiencing disinflation/deflation for almost twenty years. A debate over its cause and remedies can be roughly characterized as one over " supply versus demand." In the Japanese context, only a few studies test a theory developed by Ball and Mankiw (1995) in the area of New Keynesian economics. Many researchers interpret this as a supply-side hypothesis for short-run inflation, and suggest that the detected positive correlation between the asymmetry of sectoral relative-price changes and inflation supports the hypothesis. This paper re-examines this correlation and investigates whether monetary environment and aggregate demand can also explain the inflation rate during the quantitative easing period.

Using data on the producer price index (PPI), which is conceptually closer to the Ball and Mankiw (1995) theory than consumer price inflation, we first showed, employing their basic specification, that the positive and significant effect of relative-price change asymmetries on inflation is not robust with respect to various indicators of asymmetry. We then showed that indicators of aggregate demand and monetary environment *do* affect measures of asymmetries and, adding these to the specification, obtained results that showed particularly demand factors to play a noteworthy role in explaining inflation. In our examination of the dynamic impact of various factors on inflation, we obtain robust evidence from impulse responses based on vector autoregressive (VAR) models that demand and money influence inflation and that aggregate demand also, significantly and substantially, affects the asymmetry of relative price-changes. Overall, these results lead us to conclude that, at least for the quantitative easing period, it is too hasty to regard the recent disinflation/deflation as a supply-side phenomenon and that demand side is at least equally important as a determining factor.

At the end of this paper, some shortcomings and venues for future extension are in order. This study concentrates on the phase of quantitative easing by the Bank of Japan, and extending the period of study would be of interest. A precondition for such an analysis, however, would be to accommodate quite different indicators of monetary shocks. It may also be important to address the small sample issue pointed out by Ceccheti and Bryan (1999), possibly in line with Gerlach and Kuglar (2007). Further, the result of this study is *indicative* that money and other determinants of aggregate demand *could* have different degrees and time-profiles of influence to various sectors, but the study does not directly examine such a possibility. In this respect, direct evidence on asymmetric sectoral effects of shocks in demand and monetary policy (Hayo and Uhlenbrock, 2000, Dedola and Lippi 2005) would complement this study and strengthen its claim.

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